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ABSTRACT

This research is concerned with the pragmatic performance characteristics of competing information technologies (ITs) and services in the university research center, as measured by user demand and choice. Technologies and services studied include: (1) mediated search service operating at cost recovery, open to all; (2) end-user service collecting token charges; and (3) CD-ROM based research work stations freely available. Recorded data from the administrative information system was gathered over 15 years in an "ex post facto" analysis of the levels and patterns of use of the three competing information services. This data was supplemented by surveys of 186 graduate students concerning the values assigned to activities, perceived problems, and reported failures and successes. It was discovered that monetary cost, convenience of access, and time spent are the central factors which determine student selection and use of ITs. Users are willing to subordinate certainty of success, precision, recall, authority and currency for services which are convenient and largely free of cost. This study proved that information content is of minor importance when compared to other features such as cost and convenience when selecting an IT or service. Data is presented in three tables. (Contains 27 references.) (MAS)

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Dynamic Modelling of User Decision-Making in Selecting Information Services at a University Research Center

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Zusammenfassung

In dieser Untersuchung werden Daten, die im Laufe der letzten 15 Jahre gesammelt wurden, als *ex post facto*-Analyse der Dynamik in der Auswahl und Nutzung von Informationstechnologie präsentiert. Es werden Grundmuster der Motivation und der Auswahl erklärt und Leistungskenndaten des Systems erläutert. Eine Matrix mit Auswahlkriterien wird näher dargestellt. Der Beitrag beinhaltet eine kritische Übersicht über die einschlägige englischsprachige Literatur zu diesen Themenbereichen und bringt Beispiele zu den wichtigen Punkten. Die Daten spiegeln Messungen der Leistung der untersuchten Informationssysteme wider und bilden einen Ausgangspunkt für weitergehende und vergleichende Forschungsarbeiten.

Abstract

This research presents data gathered over the past 15 years in an *ex post facto* analysis of the dynamics of information technology service selection and use. Patterns of researcher choice and motivation are detailed, system performance characteristics are explicated, and a selection criteria matrix is detailed. This paper includes a critical review of the relevant English language research literature on these topics and is illustrated with useful examples of the salient points. Research data are provided for supplementary and comparative purposes, reflecting performance measures of the information services investigated.

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1 Introduction

Information services and technologies exist now in greater variety, providing greater options, than ever before. Perhaps nowhere more so than the university research center environment is information so highly regarded for its intrinsic value. Similarly, nowhere are access mechanisms more abundantly available or more highly used by the resident service population. While traditional print-on-paper information sources continue to be produced in ever-increasing numbers, and with greater accuracy and timeliness, it is the domain of electronic information technologies that attracts the most attention. These new technology based services also attract greater numbers of users than ever before as they become more user-friendly and demand-oriented. With these greater options for information problem solving, greater interest in their application, and ever-more sophisticated access mechanisms, information service managers and planners, along with their clientele, are increasingly challenged to make appropriate information technology applications. When access and use decisions are to be applied to resource allocations, it is essential that we understand user preference and behavior.

This present research investigates the relationship of several factors that will stand for elements of cost and thereby serve as surrogates for the measure of value associated with the information activities they measure. This research is concerned with the pragmatic performance characteristics of competing information technologies and services in the university research center as measured by user demand and choice. Following from these analyses a dynamic model of researcher decision

making is developed which offers explanations for changing patterns of service selection. Conclusions about system performance are provided which suggest implications for system design for, and representation to, researchers, information specialists, and service providers. Finally, issues of the value of information emerge providing yet another dimension to these relevant considerations.

2 Review of Relevant Research Literature

Any discussion of the economics of information eventually devolves into a discussion of costs, benefits, and value. The value ascribed to information is highly subjective, sometimes arbitrary, elusive, context dependent, use specific, abstract, practical, utilitarian, and certainly multi-dimensional; aside from these characteristics it involves money and time, skill, training, and learning for effective recognition, selection, evaluation, and application.

2.1 Value not Cost

The importance of the discussion, though, in general, resides in the explication of the differences among cost, value, and benefits. Benefits address larger, often intangible, attributes of information such as personal growth, enlightenment, or edification. Cost analyses, whether input, output, or both, concern themselves with the analysis and comparison of the cost of doing something and the concomitant material return on that investment or expenditure. While these are valuable, if not essential, they are not the direct subject of this present work.

A brief, but otherwise excellent, review of the literature is provided by Griffiths (1982). She carefully divides the extant literature into its two dominant, component considerations: 1) concepts of value and approaches to value assessment and 2) the application of value assessments to information products and services. Though the former is the more prevalent in the literature, and the latter is that of the greatest concern to the practitioner and planner, each is carefully represented in this well written and balanced discussion of the better examples in each category. Griffiths concludes with an enumeration of the lingering problems of value determination, the subjective nature of the information context, and other concerns which may serve to preclude or inhibit progress in (a) theoretical developments and understanding and (b) more numerous and substantive empirical study with either qualitative or quantitative importance. Taylor (1982) provides a complimentary theoretical discussion, the tone and significance of which is closely related to the work by Griffiths. He examines the nature of information systems as a "series of formal processes by which the potential usefulness" of information is provided. This understanding is essential, he writes, to the view that information itself is the primary component rather than the technology that supports it, or the content of the service or product in its material representation. That is to say that value is not inherent in the message itself, that the message has meaning, hence value, only in context, that the message is valued only by the user relevant to the immediate need or application, and that information becomes "value-added" by the enhancement or increase of these other categories, or by some method of improved notification or extended relevance. This work extends and builds upon other significant contributions by Taylor (1968, 1981, and 1985).

Rouse and Rouse (1984) have linked the value constructs of the individual to the need for providing

maximum flexibility in system design observing that the absence of theoretical foundation of information seeking behavior suggest that the individual's choices and actions are more valid gauges of value than the isolated elements of conflicting information value theories. Machlup (1979) develops the notion of the multiple characteristics of value including the "exchange value" of information, as distinct from the "use value" of information. By exchange value we mean that interaction by which some sort of trade or exchange is made, usually in the monetary sense, in return for the transfer of information. This value is negotiated between or among the various principals party to the transaction. This is sometimes referred to as the "willingness to pay" concept. Excellent assessments and analyses of these issues are provided by Slamecka *et al.* (1986). The work of Virgo (1987) is noteworthy for its deft handling of the varieties of "cost." Though cost *per se* is not the consideration here, only by a thorough understanding of the cost perspectives do we have much chance of fully understanding the concept of value in the practical and applied cases with which many of us are confronted daily. Repo (1989) has revitalized this approach by a thorough examination of the theoretical interpretations of the value of information. There is promise of success when use value is coupled with extended analyses of tasks performed with special reference to cognitive activities and their analysis.

Perhaps of greatest single contributor is King whose many works have appeared either singly (1977) or with others, King, McDonald & Roderer (1981), King, Griffiths, Roderer & Wiedekehr (1982), and King and Griffiths (1985). Each of these contains significant contributions to our theoretical understanding supported by solid empirical research, investigation, and interpretation. Of particular importance to this research is the work of Caroll and King (1985). Noteworthy in this context is the

explication of the "effective" price the users pay for information, which is more than merely monetary, including as it does, time and effort expended, the time or monetary savings earned by information use, and the extension of personal value represented by the "willingness to pay."

Another important contribution to this essential discussion is found in the work of Rouse (1986). He makes important distinctions in the matter of information needs and activities of individuals engaged in problem solving and information gathering activities. Rouse notes that the three most important attributes, or values, of information in the applied activities with which he is concerned are 1)reduction of uncertainty, which we may consider to be similar to authority, accuracy, and clarity; 2) task relevance with appropriate references to the difficulty of determining relevance beyond the subjectivity of the user; and 3) appropriateness of form, in which he identifies the problem of language as one difficulty to which we may add inaccessible format, absence of correct equipment for translation or use, and other limitations or restrictions on access.

2.2 Characteristics of Information System Use

From the theoretical and practical aspects of value we turn now to the characteristics of information system use. One of the earliest studies in this domain is that of Gerstberger and Allen (1968) who studied information source choice criteria. Among their many contributions was the understanding and description of *cost* as a complex concept far exceeding in its implications the monetary exchange

value so often used in these discussions. They understood that the activities of the searcher/user represented a cost to the user in terms of time, effort, and other aspects of access. That is, cost, broadly understood, is represented among dimensions which are psychological, economic and physical in nature. Their findings, with high levels of significance, represent that highest among user's criteria of choice are perceived accessibility and perceived ease of use. These factors are influential in terms of frequency of use and in concert with conceptions of quality. Rosenberg (1967) made similar discoveries as the result of his research wherein a highly significant correlation was found between the preference rankings and the ease of use of an information service, though no significant relation was found between preference and the measures relating to the amount of information derived from the source. His conclusion was that the ease of use of an information gathering method is more important than the amount of information expected in return. Morehead and Rouse (1982) attempted to study search strategy optimization testing various models of optimal and sub-optimal behavior. Their observations, in part suggested by Rosenberg's work, were that in real-life situations, human information seeking behavior is by no means precise, directed, nor refined.

Hodowanec (1979) discovered that user search strategy closely parallels the personal habits of the researcher, not in conformity with theory or protocol. Tagliacozzo and Kochen (1970) concluded that user system failures arose from failed specifications of the search strategy itself, procedural difficulties arising from the information system structure, or lack of perseverance on the part of the user. Kraft and Lee (1979) concerned themselves with stopping rules for searches; that is, at what point, and for what reason, does the searcher terminate the activity. More to the point, stopping rules address user expectations for task time investment and duration to completion. According to these

researchers the stopping rules driven by satiation or disgust or a combination are the determinants of search progress. Once again the return on the invested time, effort, and expense in relation to the information gathered is of concern.

Brown (1991) has formulated a general theory of information seeking behavior casting it as a developmental behavior over the life of the individual, revealing growing sophistication and improvement. Concisely uniting many of the heretofore empirically derived characteristics with more recent interpretations of the process as extensions of the human self, this research tends to emphasize the internal states of the individual as an operant within the individual's role and environment, as well as the context of the information gathering process. These domains are dynamic and thereby susceptible to the influences of the evolving information environment. This understanding is echoed from a different point of view in the work of Bates (1990) whose extensive researches in information seeking behaviors are widely known and respected. For her, information seeking behaviors are complex search strategies that require training, cognitive development, and analytical preparation which are incommensurate with conventional notions of convenience such as time, effort, and skill development.

Kalin (1991) has reported research describing the characteristics of local versus remote searchers of online systems. Her conclusions include the observation that remote "invisible" researchers are generally more sophisticated in their behaviors and strategies, possessing better conceptual knowledge of how information systems operate. This research is especially useful as we move toward the increasingly inter-networked information services at universities and information centers

world-wide. Users of these systems will seldom have the advantage of specific training by local experts and trainers, and must rely on their generalized conceptions and experience elsewhere. These concerns speak directly to the need for consistency of commands, data structures, and logical protocols. We might extend this reasoning to include the realization that such protocols should emanate from deeper understanding of the human information seeking paradigms, rather than attempting wide-spread adherence to protocols and algorithms. In consideration of matters of choice of information resources Pinelli *et al.* (1991) have empirically examined the factors affecting the use of various information sources. Generalizing, we may infer that accessibility, technical quality, and relevance are the attributes most highly prized by researchers. Though the precise ranking of these three properties admits to minor variation, their consistently high valuing confirms their pre-eminence among other factors.

It is clear from even this brief review that any serious consideration of use value or value-added attributes of information technology must account for not only monetary cost (exchange value) but the users willingness to pay in the broadest sense. That broadest sense includes time for training, time for the activity itself, time until completion (duration), skill development demands, travel, waiting on queues, cognitive development, and analytical or interpretive requirements among other factors. One conclusion from these historic researches is that the "value-added" to the process of information gathering is largely attributable to the individuals in context. The common identification of the characteristics such as convenience, time-on-task, ease-of-use, or accessibility speak clearly to the methods of interaction with services and the material demands on the individual. Attributes of intellectual or cognitive gain appear to be subordinated. Conversely, similar demands for

intellectual development and learning sophisticated protocols are avoided or de-valued in favour of material expediency.

We may conclude that if the information is valued by the individual by their demonstrated interest in it, and the different information sources contain the same information, varying only in the protocols and methods of information gathering, it is then reasonable to conclude that the technical systems themselves are the sources of the variant value assessments. The value added nature of the information source or service is contributed at least in part by the users own contribution of time, effort, skill, money, or development. Tangible representation of the users value is represented by the *cost* they are willing to exchange directly or the benefit they expect to derive by external measure. Cost is broadly defined but stands as the measurable surrogate, perhaps the only one possible, for the value attached, or added to the information service. We recognize that this notion of cost and value itself is a highly complex concept that admits to many facets, attributes, and factors. It is the object of this research to explicate the nature of these variables and their interplay in a dynamic model of user decision making. It is within this framework that this current research examines the relationship among information needs and their concomitant costs in an attempt to identify the dimensions of value associated with information products and services, and, ultimately, with "information" itself.

3 Observational Environment and Data Gathering

Observations were made of the use made of alternative sources of information and among competing information services in a university information environment. These services are: 1) mediated search service operating at cost recovery, open to all; 2) end-user service collecting token charges; and 3) CD-ROM-based research work stations freely available. Conducted as an *ex post facto* analysis of use data, these observations are independent of perceived intrusion and observation. Using recorded data from the administrative information system, levels of information system use at a university research center were studied to identify the levels and patterns of use over the years of three competing information services.

Service level data provided generalizable patterns of behavior. These data were supplemented by surveys conducted in classes of graduate students to gather information concerning the "values" assigned to activities and to provide some measure of equivalence across diverse factors. The preference scale was compiled and quantified to provide a measure of normalization. In the last section of the survey itself, open ended questions concerning perceived problems and reporting failures and successes provided valuable insight into the users interests. Profiting from such contributions, the survey form evolved over time to reflect the higher dimensionality of factors relevant to the information seeking behavior. Eliminating incomplete and preliminary survey forms, this study is based on the reports of 186 graduate students. Interviews with faculty members were

inconsistent, distributed over several years, and insufficient in number to yield statistically significant results. Only anecdotal representations are made for faculty at this point.

4 User Model & Behavioral Paradigm

Generalizations are extraordinarily dangerous in all instances, but seem even more so in the case of library services where needs are variable, options are multiple, and the strength of external forces and rewards is minimized. Still, we are confident enough of these observations to cast certain characteristics about information service users operating in a situation of competing choices. Students, for example, when confronted by time demands will defer to a short time-on-task solution. In just over half of the observed cases, students would substitute, omit, or alter the information request in favor of the time expedient. Students will defer consideration of reliability and authority over the time requirement or cost increment.

By contrast faculty members are less likely to defer to time or cost over information need-satisfaction. Though cost is a concern, as illustrated in the foregoing dimensions, it is less a concern than providing for the adequacy of the solution to the research need. Faculty members are more likely to pay personally for needed information contained in externally provided documents, and are more likely to wait for their arrival than students who will exercise circumlocuitous options of information use in the immediate or short-term experience. Faculty are more likely to persist in the solution of their research needs. Students are more likely to deviate from, or reformulate, the

original problem into a manageable information format that is soluble in short order with minimum expenditure and effort.

Given the vagaries of the circumstances in general and the variety of options and deterrents at work in any and all of these circumstances, it is useful to illustrate these observations in the following Value Matrix (Table 1). This matrix illustrates the relationship among "cost" variables for the three variations of electronic information retrieval service offered and discussed previously.

PRIMARY FACTORS: Information Attributes	Recall Scope	Authority Reliability	Currency	Relevance Precision
SECONDARY FACTORS: "COST" Attributes				
Skill & Performance	-2	-1	-1	+2
Cognitive Demand	-1	0	+1	+2
Certainty of Success	-2	-2	+1	+2
Penalty for omission	-1	0	+1	+1
Substitutability	-2	-1	-1	+1
Availability	-2	-2	-2	0
Training Time Required	-2	-1	-1	+1
Preparation Time	-2	+1	-1	+2
Task Application Time	-1	-2	-2	+2
Time to Completion	-1	-1	+1	+1
Time & Access Limits	-2	-2	-2	+1
Monetary Cost	-2	-2	-1	-1
Procedures	-2	0	0	0

Table 1

VALUE MATRIX
INFORMATION RETRIEVAL ACCESS MECHANISMS
STRENGTH OF FACTORS INFLUENCING SERVICE CHOICE

These cost variables are coordinated in this array with four common attributes of information. With 0 indicating neutral, values less that 0 indicate the strength of the secondary (cost) factors, while values greater than 0 represent the strength of the primary (information) factors influencing user choice. With only relevance as a strong positive influence it is clear that these individuals are more concerned with reducing their personal investment and commitment to the process rather than building strong intellectual or cognitive quality. The strongest negative values center on behaviors relating to personal effort, time, and skill development which is interpreted as a consistently powerful motivation aimed at reducing investment.

Table 2 represents the various cost factors in isolation in consideration of information attributes. The perception of costs exceeds the expectation of information gain. Monetary cost, availability of service and time and access limits are the strongest deterrents to information gathering and use. When measured against these thirteen performance demands, information is seen as a burden involving costs, broadly defined, that are more important than the information as a prized or valued (value-added, *mehr-wert*) benefit received in return.

SECONDARY FACTORS: "COST" ATTRIBUTES	
Skill & Performance	-0.50
Cognitive Demand	0.25
Certainty of Success	-0.25
Penalty for omission	0.00
Substitutability	-0.75
Availability	-1.50
Training Time Required	-0.75
Preparation Time	0.00
Task Application Time	-1.00
Time to Completion	-0.25
Time & Access Limits	-1.25
Monetary Cost	-1.50
Procedural Restrictions	-0.75
SECONDARY FACTORS: Costs Weighted Against Information Attributes: Mean	-0.64

Table 2
VALUE MATRIX
INFLUENCE OF COST FACTORS
WEIGHTED AGAINST INFORMATION ATTRIBUTES

Table 3 denotes that as information is evaluated in terms of costs only the relevance of the information is a serious qualitative concern. With all other attributes represented by negative values, it is apparent that these users are only concerned with context-specific relevance. This interpretive scale using zero (0) as the central point of neutrality of influence indicates the relative strength of these influence patterns. In this case it demonstrates that concerns for recall and scope are much less influential than relevance and precision are. The average value of the observed responses is -0.5375

representing a generally less-than-neutral valuing of information as an end of research activity. That is, the costs of performance are more "costly" than the benefits are beneficial to these respondents. A perhaps extreme interpretation would be that research work that involves gathering information, with all due consideration of its value, quality, or usefulness is, nevertheless, interpreted by the researcher as a losing proposition. By these responses, the costs outweigh the potential benefits.

PRIMARY FACTORS: Information Attributes	Recall Scope	Reliability Authority	Currency	Relevance Precision
Weighted Against Costs	-1.69	-1.00	-. 54	1.08

Table 3
VALUE MATRIX
INFORMATION ATTRIBUTES WEIGHTED BY COST FACTORS

5 Discussion

The cost factors which determine selection and use of information technologies are evident. Monetary cost, convenience of access, and time spent are the central factors. Users will subordinate certainty of success, and several qualitative standards such as precision, recall, authority, and currency for services that are available over a long and convenient schedule and are largely free of monetary cost. They will rely on skill development and lowered standards of quality with an investment of longer time to complete the task rather than conform to more structured administrative procedures and training programs. The desire of these researchers, graduate students, is for services that are convenient, readily available, easy to use, low cost, and which place low demand on their cognitive abilities or experiential skill base. Similar studies on other groups, *e. g.*, faculty and

research associates might demonstrate a greater reliance on higher quality information services and content. Only relevance is a high priority for students. The quality of that relevance is just as weak as the relevance is strong; a curious , seemingly contradictory message to be sure. The results of this investigation are largely in agreement with many of the relevant studies conducted over time and reviewed *supra*. Considerable elasticity of information value is discerned when information quality is measured against a variety of user costs. Most costs are represented as an exchange of user effort, often physical, temporal, intellectual, psychological, or financial. It is troubling to note the implication of this research that information is so poorly valued by these researchers.

It is not unwarranted to conclude that information content is of minor importance when compared to other features. This is the documented, empirical evidence provided by users. Additionally, and by extension, it may well be that users view all database information as equivalent and of uniform quality. Information scientists, by their experience, and advanced researchers, by their knowledge, know that this is an incorrect assumption. This user fallacy may explain the otherwise contradictory results which place recall, scope, reliability, and authority in almost complete opposition to concerns for relevance and precision. The user's choice and preference is based on ease of use and that which involves the least effort regardless of the consequences as measured in terms of quality.

We are struck by the seeming contradiction: the value-added is somehow maximized not by the increase in qualitative return, rather by reducing the investment *i.e.*, the cost. It would appear that information may be viewed as a commodity with fixed cost (value) against which a variable investment (*e. g.* time, effort, skill, money) is made. Under such a materialist interpretation it is wise

to reduce the expense thereby increasing or maximizing the return on the investment. The value-added then may be found as a reduced investment in an expected, or fixed, return on that investment.

Upon inspection, valuable lessons may be learned from these experiences with the introduction and use of information technologies. With database content essentially the same our attention is drawn to user preference and the value-added nature of systems themselves and user performance and behavior. This process of disintermediation, though, reveals other characteristics of information use on the part of users; the resultant assessment of costs provides insight into the valuation of information on the part of the user. These insights have implications for the development of realistic information retrieval services and materials.

6 Conclusion

Technological innovation has rewritten the information access equation. The valuation equation now tends toward ease and convenience of use in the absence of dollar cost or financial investment in equipment and the increased willingness to submit to organizational, institutional, or bureaucratic limitations and to invest time and physical effort in the satisfaction of an information seeking problem, with the possibility or error and omission, rather than expend funds for a fast, sure, guaranteed product. The unprecedented growth of INTERNET access and use, and the increasing use of other, highly sophisticated information technologies should not be attributed exclusively, or even mainly, to a romance with the keyboard and monitor/vdt/crt. Issues of cost, convenience, and

efficiency are found to be extremely influential in these decision activities. Skill levels are subordinated to a reliance on trial-and-error behavior. Rather than quickly and efficiently enter, point, retrieve, and transfer, the more typical user, if this research has any predictive qualities or merit at all, will meander and gather indiscriminantly, moving whichever way the gopher points. The implications for channel capacity, delays, and system features to facilitate searching are significant.

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